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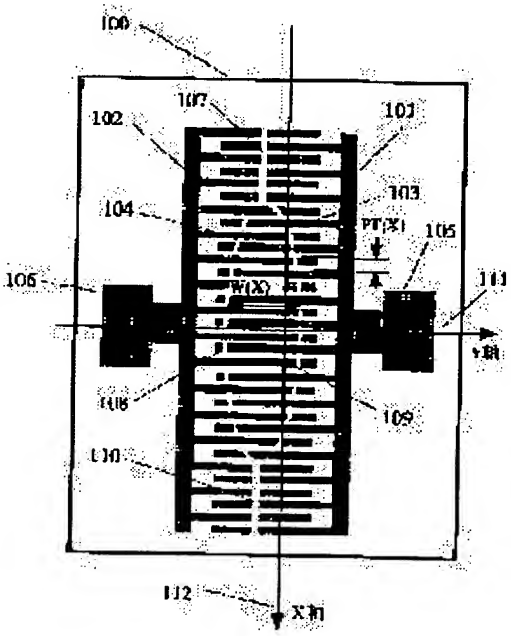
(54) SURFACE ACOUSTIC WAVE DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To make a device small in size and improved in performance by setting an electrode finger cyclic length such that it around the center of plural interdigital electrodes it constitute a resonator having a specific conductor width as to have different values from electrode finger cyclic length on both sides.

SOLUTION: Interdigital electrodes(IDT) are formed by alternately and arranging in parallel electrode fingers 103 and 104 of positive and negative polarities on positive and negative supply conductors 101 and 102 with them crossed in the phase propagation direction of an surface acoustic wave on a piezoelectric substrate 100. The conductor width of the fingers 103 and 104 is set to almost 1/4 wavelength λ, and also an electrode finger cyclic length PTc which is near the center and electrode finger cyclic length PTs on both sides have different values. That is, when the propagation coefficient of a surface acoustic wave caused by the substrate 100 and the IDT is negative, it is of a frequency- increasing type that meets a condition PTc<PTs, and when a coefficient is positive, it is of a frequency-decreasing type which meets a condition PTc>PTs. Further, the electrode finger cyclic length PT has gradual changes according to an X coordinate position through prescribed rules.



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CLAIMS

[Claim(s)]
[Claim 1] In the surface-acoustic-wave equipment which intersects perpendicularly in the phase propagation direction of a surface acoustic wave, forms the blind-like electrode which comes to carry out parallel arrangement of the positive and negative polar metallic conductor by turns, and is used as a resonator on piezo-electric-crystal monotonous Nothing [of the wavelength lambda of the surface acoustic wave which the conductor width of the electrode finger of the aforementioned blind-like electrode uses / 1/about 4 and nothing], and the aforementioned blind-like electrode Surface-acoustic-wave equipment characterized by having the value from which it is classified into at least three or more fields, and the cycle length PTc of the aforementioned electrode finger near a center differs to the aforementioned electrode finger cycle length PTs of the field of both sides.
[Claim 2] When PTc and electrode finger cycle length of both sides are set to PTs, the electrode finger cycle length near [aforementioned] a center [when the coefficient a representing the dispersion relation concerning propagation of the surface acoustic wave by the aforementioned piezo-electric-crystal substrate and the aforementioned blind-like electrode is negative] Surface-acoustic-wave equipment according to claim 1 characterized by having considered as the frequency bottom-up type which fulfills the conditions of PTc<PTs, and considering as the frequency descent type which fulfills the conditions of PTc>PTs when the aforementioned coefficient a is positive.
[Claim 3] WF(X) =COS where the aforementioned blind-like electrode has the positive/negative electrode finger of M pair, and the intersection width of face of an electrode finger takes the value of 1 in the center -- the surface-acoustic-wave equipment according to claim 1 characterized by having weighting of (KX) and giving the value of K by K=pi/(xiM) as 0.5< xi<0.9
[Claim 4] Have weighting of (KX) and the value of K is set to 0.5< xi<0.9. WF(X) =COS where the intersection width of face of an electrode finger takes the value of 1 in the center in the aforementioned blind-like electrode -- Surface-acoustic-wave equipment according to claim 3 characterized by being referred to as WF=0 more than the absolute value of X which gives by K=pi/(xiM) and is set to aforementioned function WF(X) =COS(KX) =0.
[Claim 5] the ratio of Above PTs and Above PTc -- the surface-acoustic-wave equipment according to claim 2 characterized by making PTs/PTc into the range of the ratios fR0/fT0 of 1 as mentioned above the reflective center frequency fR0 at the time of considering mostly that the aforementioned blind-like electrode is a reflector, and the frequency of the maximum fT0 of admittance
[Claim 6] the ratio of Above PTc and Above PTs -- the surface-acoustic-wave equipment according to claim 2 characterized by making PTc/PTs into the range of the ratios fT0/fR0 of 1 as mentioned above the reflective center frequency fR0 at the time of considering mostly that the aforementioned blind-like electrode is a reflector, and the frequency fT0 of the maximum of admittance
[Claim 7] the aforementioned piezo-electric-crystal plate is 128 degreeY cut X propagation a ratio with the wavelength lambda of the surface acoustic wave to the thickness H of the aforementioned electrode finger -- surface-acoustic-wave equipment according to claim 1 characterized by having made H/lambda into 0.5 to 2% of range, and being referred to as PTs/PTc=1 to 1.02

[Claim 8] the aforementioned piezo-electric-crystal plate is 128 degreeY cut X propagation a ratio with the wavelength lambda of the surface acoustic wave to the thickness H of the aforementioned electrode finger -- surface-acoustic-wave equipment according to claim 1 which makes H/lambda 4 to 6% of range, and is characterized by setting the value of PTc/PTs=1.008 to 1.02, and xi to 0.6 to 0.85

[Claim 9] a ratio with the wavelength lambda of a surface acoustic wave [as opposed to / the aforementioned piezo-electric-crystal plate is 128 degreeY cut X propagation, and / the thickness H of the aforementioned electrode finger] -- the surface-acoustic-wave equipment according to claim 1 characterized by having made H/lambda into 3 to 3.5% of range, having set up the ratio of Above PTc and Above PTs almost equally, and considering as a filter ability use

[Claim 10] the logarithm of the electrode finger of the aforementioned blind-like electrode -- the surface-acoustic-wave equipment according to claim 8 characterized by M considering as 50 to 250 pairs

[Claim 11] the aforementioned piezo-electric-crystal plate is crystal a ratio with the wavelength lambda of the surface acoustic wave to the thickness H of the aforementioned electrode finger -- surface-acoustic-wave equipment according to claim 1 characterized by having made H/lambda into 2 to 5% of range, and being referred to as PTs/PTc=1.007 to 1.02

[Claim 12] the logarithm of the electrode finger of the aforementioned blind-like electrode -- the surface-acoustic-wave equipment according to claim 11 characterized by M considering as 100 to 300 pairs

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the resonator constituted using a surface acoustic wave and a resonator type filter, and the surface-acoustic-wave equipment which realized [in / fields, such as a transversal type filter, / further] the miniaturization of size.
[0002]
[Description of the Prior Art] The resonator and resonator type filter etc. is known as the 1st kind in conventional surface-acoustic-wave equipment. these become at least one blind-like electrode (it omits henceforth and IDT is called) from at least one pair of reflectors (JP,7-73177,B -- JP,4-52005,B-refer to) Moreover, the example of the horizontal multiplex mode filter which combined the resonator of only Above IDT and this is indicated by JP,58-12418,A. The example of an IDT type resonator which consists of composition of only IDT is given to JP,6-85602,A further again.
[0003] Moreover, as the 2nd kind of surface-acoustic-wave equipment, there is a transversal type filter using IDT which consists of a double division electrode (a 1/8-wave electrode) etc. (JP,2-45368,B).
[0004]
[Problem(s) to be Solved by the Invention] however, in the case of JP,7-73177,B and JP,4-52005,B which are the conventional technology belonging to the 1st above-mentioned kind The size of the propagation direction of a surface acoustic wave [in / a resonator and resonator type filter / only in the part which uses a reflector] becomes long. The technical problem that the miniaturization of the element required of the intermediate frequency filter (IF filter) used for the cellular phone of the GSM method which shows development remarkable in recent years, or a PHS method cannot be performed occurs. moreover, with the technology of the so-called IDT resonator shown in conventional JP,58-12418,A and conventional JP,6-85602,A The Q value (numeric value which shows the degree of resonance acute) of a resonator was as small as thousands, and an equivalent-series-resistance value small enough was not acquired, but there was a fault that the insertion loss of a filter became large.
[0005] moreover, with the conventional technology belonging to the 2nd above-mentioned kind, such as a transversal type filter (JP,2-45368,B), since an electrode digit was set to about 1 micrometer and needed in general the manufacturing installation which is an expensive aligner etc. in manufacture when the frequency of an element becomes high with 400MHz, since 1/8 wave of electrode finger is used, there was a fault of becoming cost quantity
[0006] Then, this invention solves such a trouble and the 1st purpose is achieving a miniaturization further, without spoiling the performance as much as possible in surface-acoustic-wave equipments, such as a resonator and resonator type filter. Moreover, the electrode finger of the same quadrant wavelength width of face as a resonator is used for the 2nd purpose. It is ******, and manufacturing installations, such as an expensive aligner, are not needed but it is in providing a commercial scene with the filter of the transversal type which has the performance of the same level as the former, or an IDT type by the low cost.
[0007]
[Means for Solving the Problem]

(1) In the surface-acoustic-wave equipment which the elastic-wave surface equipment of this invention intersects perpendicularly in the phase propagation direction of a surface acoustic wave, forms the blind-like electrode which comes to carry out parallel arrangement of the positive and negative polar metallic conductor by turns on piezo-electric-crystal monotonous, and is used as a resonator Nothing [of the wavelength lambda of the surface acoustic wave which the conductor width of the electrode finger of the aforementioned blind-like electrode uses / 1/about 4 and nothing], and the aforementioned blind-like electrode It is characterized by having the value from which it is classified into at least three or more fields, and the aforementioned electrode finger cycle length PTc near a center differs to the aforementioned electrode finger cycle length PTs of the field of both sides.

[0008] (2) In the above (1), when the coefficient a representing the dispersion relation concerning propagation of the surface acoustic wave by the aforementioned piezo-electric-crystal substrate and the blind-like electrode is negative, it considers as the frequency bottom-up type which fulfills the conditions of PTc<PTs, and when the aforementioned coefficient a is positive, it is characterized by considering as the frequency descent type which fulfills the conditions of PTc>PTs.

[0009] (3) It is characterized by giving by K=pi/(xiM), having weighting of the above (WF(X) =COS(KX to which a blind-like electrode has M pairs of positive/negative electrode fingers, and the intersection width of face of an electrode finger takes the value of 1 in the center in 1)), and using the value of K as 0.5< xi<0.9.

[0010] (4) Have weighting of the above (WF(X) =COS(KX to which the intersection width of face of an electrode finger takes the value of 1 in the center in the blind-like electrode of 1)), and set the value of K to 0.5< xi<0.9. It is characterized by being referred to as WF=0 more than the absolute value of X which gives by K=pi/(xiM) and is set to aforementioned function WF(X) =COS(KX) =0.

[0011] (5) the above (2) -- setting -- the ratio Of Above PTs and Above PTc -- it is characterized by making PTs/PTc into the range of the ratios fR0/fT0 of 1 as mentioned above the reflective center frequency fR0 at the time of considering mostly that the aforementioned blind-like electrode is a reflector, and the frequency of the maximum fT0 of admittance

[0012] (6) the above (2) -- setting -- the ratio Of Above PTc and Above PTs -- it is characterized by making PTc/PTs into the range of the ratios fT0/fR0 of 1 as mentioned above the reflective center frequency fR0 at the time of considering mostly that the aforementioned blind-like electrode is a reflector, and the frequency fT0 of the maximum of admittance

[0013] (7) a ratio with the wavelength lambda of a surface acoustic wave [as opposed to / in the above (1), a piezo-electric-crystal plate is 128 degreeY cut X propagation, and / the thickness H of the aforementioned electrode finger] -- it is characterized by having made H/lambda into 0.5 to 2% of range, and setting PTs/PTc to 1 to 1.02

[0014] (8) a ratio with the wavelength lambda of a surface acoustic wave [as opposed to / in the above (1), a piezo-electric-crystal plate is 128 degreeY cut X propagation, and / the thickness H of the aforementioned electrode finger] -- it is characterized by having made H/lambda into 4 to 6% of range, and setting the value of PTc/PTs=1.008 to 1.02, and xi to 0.6 to 0.85

[0015] (9) a ratio with the wavelength lambda of a surface acoustic wave [as opposed to / in the above (1), a piezo-electric-crystal plate is 128 degreeY cut X propagation, and / the thickness H of the aforementioned electrode finger] -- it is characterized by having made H/lambda into 3 to 3.5% of range, having set up Above PTc and Above PTs almost equally, and making them into a filter ability use

[0016] (10) the above (8) -- setting -- the logarithm of the electrode finger of a blind-like electrode -- it is characterized by M considering as 50 to 250 pairs

[0017] (11) in the above (1), a piezo-electric-crystal substrate is crystal a ratio with the wavelength lambda of the surface acoustic wave to the thickness H of the aforementioned electrode finger -- it is characterized by having made H/lambda into 2 to 5% of range, and setting PTs/PTc to 1.007 to 1.02

[0018] (12) the above (11) -- setting -- the logarithm of the electrode finger of a blind-like electrode -- it is characterized by making M into 100 to 300 pairs

[0019]
[Embodiments of the Invention] Hereafter, order is explained for the gestalt of operation of this invention later on from drawing 1 .
[0020] (Example 1) Drawing 1 is the gestalt of the 1 operation which expressed with the plan the electrode pattern used for the surface-acoustic-wave equipment of this invention. the name of each part grade in drawing 1 -- 100 -- a piezo-electric-crystal plate and 101 -- electric supply of straight polarity -- a conductor -- 102 -- electric supply of negative polarity -- a conductor, and 103 and 104 grades -- the electrode finger of IDT, and each electric supply -- 105 and 106 linked to conductors 101 and 102 -- the pad for an external flow -- The parting line from which 107,108,109 and 110 grades make IDT electrode finger intersection width-of-face W (X), and 111 are Y-axes which are the directions which intersect perpendicularly with the X-axis of 112, and 112 is the X-axis which shows the phase propagation direction of a surface acoustic wave. The piezo-electric-crystal plate of 100 consists of what carried out mirror polishing of the front face of the single crystal which has piezoelectric [, such as crystal, a lithium tantalate, and a lithium niobate,], a substrate which formed piezoelectric thin films, such as ZnO, further. After carrying out thin film formation of the metal membrane which has the conductivity of aluminum, gold, etc. by meanses, such as vacuum evaporationo and a spatter, pattern formation of the conductor patterns, such as IDT formed on above 100, is carried out with photolithography technology, and they are made. Above IDT -- electric supply of straight polarity -- electric supply of a conductor 101 and negative polarity -- although it consists of electrode finger 104 grades of a conductor 102, the electrode finger 103 of straight polarity linked to these, and negative polarity, the electrode **** intersects perpendicularly to the phase travelling direction (longitudinal direction X-axis) of the surface acoustic waves (the Rayleigh wave or Leakey wave) to be used, and is arranged in parallel and periodically [much] By the parting lines 107 and 110 of Above IDT, the intersection width of face of the electrode finger of straight polarity and negative polarity is made with zero. Moreover, W (X) whose IDT parting line of 108 and 109 is a width-of-face size which the electrode finger of a positive electrode and a negative electrode intersects has weighting of COS(KX). The electrode finger cycle length PT (X) which constitutes Above IDT has given stairway-change an X coordinate position under the specific rule in drawing 2 mentioned later further again.
[0021] (Example 2) Below, other examples of this invention are used for drawing 2 , and it shows the example of a concrete setting of the electrode finger cycle length PT in above-mentioned drawing 1 (X). The range by which 200 was surrounded for the name of each part grade in drawing by the piezo-electric-crystal plate and the dotted line of 201 is an IDT type SAW resonator, and 202 and 209 are the pads for external connection. The field where electrode finger intersection width of face is the field of zero, and the field surrounded with the dashed line of 203 and 204 is shown with the dashed line of 214 is a field which has uniform electrode finger intersection width of face. 205 and 206 grades -- an electrode finger, and 207 and 208 grades -- electric supply -- it is a conductor Naming the stair-like function FP of 212 (X) the frequency potential function which determines the electrode finger length of Above IDT, curvilinear [of 213] V (X) is oscillating displacement function obtained in the example of drawing 2 .
[0022] The frequency potential function FP of the above 212 (X) is determined by the kind and the quality of the material of the piezo-electric-crystal plate 200. In the case of the example of drawing 2 , it is a setup in a case like a crystal ST cut-X propagation substrate, and the cycle length PT of an electrode finger (X) is short set up stair-like like the center of the X-axis. The aforementioned PT (X) is set up by the following formula (1) considering VS as a speed of a surface acoustic wave in case there is no aluminum film.
[0023]
[Equation 1]

$$(1+FP(X))\ f_{R0}=V_S/(2\cdot PT(X)) \qquad (1)$$

[0024] the electrode finger which connects between 209 with the positive/negative electrode pad 202 too hastily, and is produced in the IDT type SAW resonator of the drawing 2

configuration produced when frequency fR0 used as the criteria in a formula (1) is set to aforementioned PT(X) =PT0 (fixed) -- a conductor -- it is the center frequency of the reflection property which a group makes

[0025] Above FP (X) has the dimension of frequency rate of change.

[0026] Moreover, the frequency given by formula fi =VS/(2 and PTi (X)) is used for zetai (i=0-3) expressed with the frequency rate of change in drawing 2 , and it is [0027].

[Equation 2]

$$\zeta_i = (f - f_{R0}) / f_{R0} \quad (2)$$

[0028] It is come out and given. zeta 0 corresponds to the frequency f0 in case there is no aluminum film especially -- it is given by f0= VS/(2 and PT0) Oscillating displacement V (X) obtained by FP (X) of drawing 2 had the variation rate of the shape of a cosine function (COS(KX)) which serves as the maximum in the center of an IDT type resonator mostly, and the so-called vibrational-energy ****** phenomenon has realized it about X shaft orientations. The reason which this phenomenon generates is explained using following drawing 3 .

[0029] drawing 3 -- setting -- 300 and 301 -- electric supply -- a conductor, and 305 and 306 grades -- the electrode finger of IDT -- The IDT field where the field surrounded by the line of 302 has the cycle length PT 1 (=Ln-1+Sn-1) of the 1st electrode finger, 303 is the cycle length PT 2 (=Ln+Sn) of the 2nd electrode finger similarly. The IDT field which it has, and 304 are IDT fields which have the cycle length PT 3 (=Ln+1+Sn+1) of the 3rd electrode finger. Moreover, omega1, omega2, omega3 which were indicated all over drawing It is the thing of the admittance property which corresponding IDT of a field has mostly called the angular frequency (omega0=2pifT0) or the Bragg frequency of the maximum point. Moreover, drawing of the inside surrounded by the frame describes the wave number dispersion curve which each above IDT has, and this property is illustrated as the wave number K of vibration-amplitude [of a surface acoustic wave] V (X) from which an angular-frequency omega=2pif shaft makes a vertical axis, and it makes a horizontal axis. Moreover, the left half plane of drawing 3 expresses the imaginary part of K, and the right half plane expresses the real part of K. The wave number dispersion curve of 307 is the thing of the IDT field 302, and 308 is the thing of the IDT field of 304. The aforementioned dispersion curve can be approximated in general by the following formula (3).

[0030]

[Equation 3]

$$\omega / \omega_0 = 1 + a\gamma^2 \quad (3)$$

[0031] Here, it is the standardization wave number to which the aforementioned Bragg frequency and a can give omega 0 to by the coefficient, and gamma is given on the wavelength lambda of a surface acoustic wave in Above K and which carried out wave number k0 (=2 pi/lambda) standardization (gamma=K / k0). Curves 307 anda are the cases where 308 are negative. It is added that a coefficient a is determined according to the kind of the kind of substrate, a direction, and surface acoustic wave. The surface acoustic wave in the state where a wave number dispersion curve takes an imaginary number value is reflected without the ability spreading, and the surface acoustic wave which has the wave number of the real number on the contrary can be spread. In the central IDT field 303, although the surface acoustic wave which has the angular frequency of omega 2 is emitted to the both sides of the X-axis, since it has the wave number K2 (real number) of 307 dispersion curves [P2], the state of the surface acoustic wave which advanced to the IDT302 side first can be spread. The surface acoustic wave which advanced to the right-hand side field of IDT304 on the other hand is reflected without the ability spreading, in order to take the wave number K1 (imaginary number) of 308 dispersion curve [P1]. Therefore, the aforementioned coefficient a is negative and the frequency setting state of IDT what can be said from the above omega1>omega2> omega 3 When it has a relation, a surface acoustic wave is reflected in the right direction of the X-axis, without the ability spreading, I hear that the amplitude is decreased and there is. further -- this -- pushing -- omega 1<omega 2> omega3 if a relation is made, a surface acoustic wave will be confined in the central IDT field which has the angular

frequency of omega 2 -- ******** -- 213 in above-mentioned drawing 2 vibration of V (X) -- a variation rate will be realized The above omega1, omega2, and omega3 is omega1=2pifT1, omega2=2pifT2, and omega3=2pifT3. It can set and can be made to correspond with zeta2, zeta1, and zeta2 in order due to a formula (2).

[0032] Next drawing 4 is used and it is 128-degreeY-XLiNbO3 as an example of the piezo-electric-crystal plate in drawing 1 and drawing 2 . The construction of the surface-acoustic-wave equipment of this invention is explained using the example of a substrate. As for IDT of drawing 4 , the electrode digit L consists of length of quadrant wavelength (lambda/4).

[0033] the horizontal axis of drawing 4 -- an aluminum electrode layer -- thick -- the ratio of the wavelength lambda of the surface acoustic wave to H -- it is H/lambda and the vertical axis shows frequency rate-of-change deltaf/f per ppm The curve 400 is displayed by frequency rate of change by making into a reference value 0 frequency f0= VS/(2 and PT0) in case there is no aluminum film about the frequency fT0 of the admittance maximum point which Above IDT has. A curve 401 is electrode finger thickness ratio H/lambda of the center frequency fR0 of the reflection property which Above IDT has. The dependency is illustrated. 402 is what was taken and drawn so that the delta frequency of 402 and 401 may become equal to the delta frequency of 401 and 400, and the field across which it faced by 400 and 402 expresses, the reflective field, i.e., the stop band, of a surface acoustic wave. It crosses in about H/lambda= 3.2, the aforementioned stop band has disappeared in this state, and curves 400 and 401 spread a surface acoustic wave, without being reflected. Therefore, in the conditions of this thickness ratio, an electrode digit L can realize [the composition of the filter which is a ****** element] reflection of a transversal type, an IDT type, and that surface acoustic wave by 1/about 4 wave (lambda/4) of length. H/lambda of a reflection coefficient is sufficiently small effective in efficiency in the range which is about 3 - 3.5%. If H/lambda sets to 3.2 or less field, it is fT0<fR0. Being in a state, the surface acoustic wave of this field serves as the property of the dispersion curves 403 and 404 illustrated in piles all over drawing, and shows a frequency bottom-up type ****** state as the so-called example of above-mentioned drawing 2 . It is reverse. If H/lambda sets to 3.2 or more fields, it is fT0>fR0. Being in a state, the surface acoustic wave of this field serves as the property of the dispersion curves 405 and 406 illustrated in piles all over drawing, and the example of above-mentioned drawing 2 shows the so-called frequency descent type ****** state of a reverse property. If it collects, the example of above-mentioned drawing 2 corresponds to above eye frequency bottom-up type ******. It is the construction corresponding to the field not more than H/lambda <3.2 of drawing 4 . H/lambda> In the case of 3.2, if zeta 1 to zeta 3 of drawing 2 is set up as negative, a frequency descent type energy ****** state can be constituted. vibration of the elastic surface equipment of this invention obtained by next doing in this way -- a variation rate -- drawing 5 explains a state

[0034] The horizontal axis 504 of drawing 5 expresses the X coordinate of surface-acoustic-wave equipment to the square of vibrational-energy E(X) (oscillating displacement-amplitude U of an element, and a vertical axis 503 expresses proportionality). The curves 500-502 in drawing are functions which show the vibrational-energy distribution according to condition. IDT201 of drawing 2 of the above-mentioned [the thing used as the aforementioned conditions] -- trichotomizing -- the amount P of frequency elevation of IDT of the center (frequency potential) -- aforementioned | fT0-fR0 | =eta -- a unit -- carrying out -- the case of 500 -- P= -- the case of 0eta and 501 -- P= -- in the case of 0.8eta and 502, it is the case where it sets up with P=1.2eta When P is not zero, it turns out to the amount 0 of frequency elevation that the main degree of concentration of vibrational energy is increasing, as this drawing shows.

[0035] What expressed this phenomenon still more intelligibly is the property view (drawing 6) showing the Q value of the resonator which is surface-acoustic-wave equipment of drawing 2 . As everyone knows, the Q value of a resonator expresses the grade of the energy loss of a resonator, and it is a good resonator with little loss, so that Q is large. The horizontal axis of drawing 6 is the aforementioned amount P of frequency elevation of Center IDT, and the vertical axis is expressed on the basis of resonator Q value Q0 in P= 0. It turns out as eta=

8000 ppm that about 4 times as many Q value as this is obtained at the time of P=1.2eta. a ratio with the wavelength lambda of a surface acoustic wave [as opposed to / value / concrete / of the above P with which the Q value elevation effect is accepted] the thickness H of the aforementioned electrode finger in the case of a crystal ST cut X propagation direction / -- H/lambda -- 2 to 5% of range -- carrying out -- 7000-20000 ppm -- ****** (the ratio which are the central electrode finger cycle length PTc and the electrode finger cycle length PTs of both sides at this time is PTS/PTc=1.007-1.02) 128-degreeY-XLiNbO3 a ratio with the wavelength lambda of a surface acoustic wave [as opposed to the thickness H of the aforementioned electrode finger in the case of a substrate] -- H/lambda was made into 4 to 6% of range, and it was 8000-20000 ppm (the ratio of the central electrode finger cycle length PTc and the electrode finger cycle length PTs of both sides is PTc/PTs=1.008-1.02 at this time) furthermore, a piezo-electric-crystal plate is 128 degreeY cut X propagation a ratio with the wavelength lambda of the surface acoustic wave to the thickness H of the aforementioned electrode finger -- H/lambda is made into 0.5 to 2% of range, and improvement in Q value can be realized also as PTs/PTc=1 to 1.02 The logarithm of the positive/negative electrode finger used for Above IDT is 128-degreeY-XLiNbO3. In the case of a substrate, the ranges of the case of 50-250 pairs and a crystal ST cut X propagation direction are 100 to 300 pairs.

[0036] Below, the unnecessary resonance generated to the surface-acoustic-wave equipment of this invention, i.e., the suppression means about spurious one, is explained. Above-mentioned 128-degreeY-XLiNbO3 as an example The example of a substrate is taken and it explains. In the aforementioned substrate, if electrode thickness ratio H/lambda is set as 0.05 and a frequency descent type energy ****** type resonator is constituted, it will generate spurious one by vertical in harmonic mode to the S0 mode up side which is the main resonance mode. This situation is shown in drawing 8 . The mode of 804 and 805 displayed by the dotted line in drawing is spurious. 802 is the aforementioned main resonance mode and 803 is antiresonance mode.

[0037] Then, in order to oppress spurious one of this, it is drawing 7 which considered weighting function WF(X) =COS(KX) to the electrode finger intersection width of face of Above IDT (refer to drawing 1), called the above xi at the time of giving a setup of Above K by K=pi/(xiM) weighting length ratio, and illustrated the relation of amount of phase change deltaphi of the impedance of the resonator by the spurious resonance to xi. It means that amount of phase change deltaphi had performed spurious suppression, so that deltaphi is small, since the generating intensity in spurious mode is expressed. It is the coordinate of X (= x/lambda) shaft orientations standardized on the wavelength lambda of the aforementioned X wave surface acoustic wave. The curve 700 of drawing 7 was the case of the amount P= 0 of frequency elevation, xi= 0.8 was the minimum value at this time, when it was a curve 701, it was aforementioned P=0.8eta, and 0.65 was the minimum value at this time. 702 was the case of P=1.2eta and the minimum value at this time was 0.5.

[0038] Therefore, 128-degreeY-XLiNbO3 In the case of a substrate, it can oppress spurious one in the conditions of P= 0 to 1.2 to the range of xi= 0.5 to 0.9. The almost same inclination was shown also about other substrate directions.

[0039]

[Effect of the Invention] As stated above, according to this invention, not using a reflector, a resonator is constituted only from IDT. The property of the piezo-electric substrate which uses the electrode finger cycle length of IDT which divided Above IDT into plurality, and also was each divided By corresponding to a frequency bottom-up type or a frequency descent type, and setting up frequency potential so that the vibrational energy of a resonator may be concentrated and shut up in the center There is nothing to the former, it is small, and the IDT type resonator which was excellent in the performance, and since a width and vertical multiplex-mode type resonator type filter is realizable using this, it can contribute to the miniaturization of carried type communication devices, such as PHS, GSM, etc. as which a miniaturization is required further, VCSO, etc. Moreover, when it becomes possible to oppress spurious one which consists of a vertical in harmonic mode group by making K of cosine-function COS(KX) proper and performing electrode finger weighting of Above IDT and the surface-acoustic-wave equipment of this invention is used for a filter etc., the damping

property which was excellent, without being blocked by aforementioned spurious one can be acquired.

[0040] It is 128-degreeY-XLiNbO3 further again. In a substrate, since an electrode digit L can realize the state where reflection of a surface acoustic wave does not occur on quadrant wavelength, either, by setting up thickness ratio H/lambda of an electrode finger with about 0.032, even if it does not use advanced processing equipment, a hundreds of MHz SAW filter can be realized, reduction of element cost is attained, and great profits can be expected from now on.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The plan showing one example of the surface-acoustic-wave equipment of this invention.
[Drawing 2] Drawing which other examples of this invention show.
[Drawing 3] The conceptual diagram which explains the principle of operation of the surface-acoustic-wave equipment of this invention.
[Drawing 4] The property view of a piezo-electric-crystal plate which one example of this invention shows.
[Drawing 5] The property view which drawing 1 and drawing 2 of this invention have.
[Drawing 6] The property view which drawing 1 and drawing 2 of this invention have.
[Drawing 7] The property view which drawing 1 of this invention has.
[Drawing 8] Other property views which drawing 1 of this invention shows.
[Description of Notations]
100 Piezo-Electric-Crystal Plate
101 Electric Supply of Positive Electrode -- Conductor
102 Electric Supply of Negative Electrode -- Conductor
103 Electrode Finger of Positive Electrode
104 Electrode Finger of Negative Electrode

[Translation done.]

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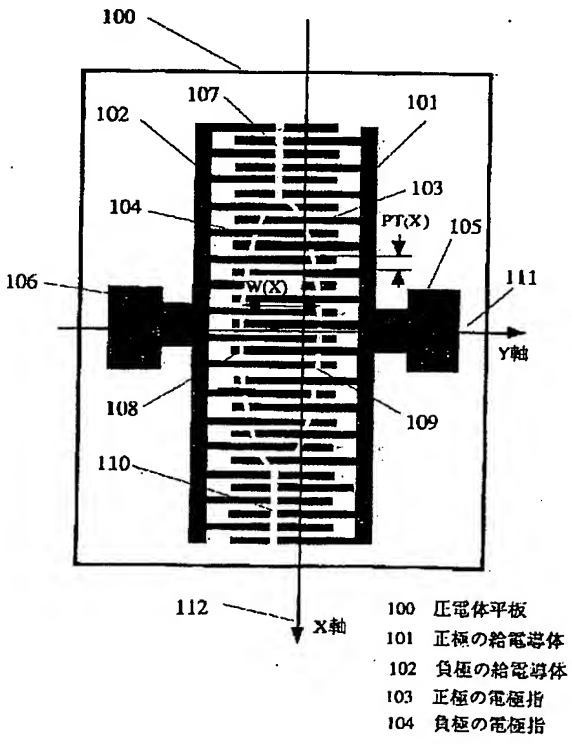
(54)【発明の名称】　弾性表面波装置

(57)【要約】

【課題】本発明は、ＩＤＴのみで構成したＩＤＴ型ＳＡＷ共振子のＱ値向上とスプリアスを抑圧し、これを用いて小型で性能がよ良い、横および縦多重モードフィルタ等を実現する。

【解決手段】ＩＤＴを複数に分割したうえに、各分割されたＩＤＴの電極指周期長を使用する圧電基板の性質が、周波数上昇型か周波数降下型かに対応して周波数ポテンシャルを共振子の振動エネルギが中央に集中して閉じ込められる様に設定することにより、従来なく小型で性能のすぐれたＩＤＴ型共振子と、これを用いて横及び縦多重モード型の共振子型フィルタを実現できる。



1

【特許請求の範囲】

【請求項１】　圧電体平板上に、弾性表面波の位相伝搬方向に直交して正と負の極性の金属導体を交互に平行配置してなるすだれ状電極を形成し共振子として使用する弾性表面波装置において、

前記すだれ状電極の電極指の導体幅は、利用する弾性表面波の波長λのほぼ４分の１となし、

前記すだれ状電極は、少なくとも３つ以上の領域に区分されて、かつ中央付近の前記電極指の周期長ＰＴｃが両側の領域の前記電極指周期長ＰＴｓに対して異なる値を有することを特徴とする弾性表面波装置。

【請求項２】　前記中央付近の電極指周期長をＰＴｃ、両側の電極指周期長をＰＴｓとした場合に、前記圧電体基板と前記すだれ状電極による弾性表面波の伝搬に係わる分散関係を代表する係数ａが負の場合においては、ＰＴｃ＜ＰＴｓの条件を満たす周波数上昇型とし、前記係数ａが正の場合には、ＰＴｃ＞ＰＴｓの条件を満たす周波数降下型としたことを特徴とする請求項１記載の弾性表面波装置。

【請求項３】　前記すだれ状電極はＭ対の正負電極指を持ち、電極指の交差幅が中央で１の値をとるＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）の重み付けを有しており、かつＫの値を、０．５＜ξ＜０．９として、Ｋ＝π／（ξＭ）で与えたことを特徴とする請求項１記載の弾性表面波装置。

【請求項４】　前記すだれ状電極において、電極指の交差幅が中央で１の値を取るＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）の重み付けを有しており、かつＫの値を０．５＜ξ＜０．９として、Ｋ＝π／（ξＭ）で与え、かつ前記関数ＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）＝０となるＸの絶対値以上においてＷＦ＝０としたことを特徴とする請求項３記載の弾性表面波装置。

【請求項５】　前記ＰＴｓと前記ＰＴｃの比ＰＴｓ／ＰＴｃを１以上から、ほぼ前記すだれ状電極を反射器と見なした場合の反射中心周波数ｆＲ０とアドミタンスの最大値ｆＴ０の周波数の比ｆＲ０／ｆＴ０の範囲としたことを特徴とする請求項２記載の弾性表面波装置。

【請求項６】　前記ＰＴｃと前記ＰＴｓの比ＰＴｃ／ＰＴｓを１以上から、ほぼ前記すだれ状電極を反射器と見なした場合の反射中心周波数ｆＲ０とアドミタンスの最大値の周波数ｆＴ０の比ｆＴ０／ｆＲ０の範囲としたことを特徴とする請求項２記載の弾性表面波装置。

【請求項７】　前記圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを０．５から２％の範囲とし、ＰＴｓ／ＰＴｃ＝１から１．０２としたことを特徴とする請求項１記載の弾性表面波装置。

【請求項８】　前記圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを４から６％の範囲とし、ＰＴｃ／ＰＴｓ＝１．００８から１．０２、かつξの値を０．６

2

から０．８５としたことを特徴とする請求項１記載の弾性表面波装置。

【請求項９】　前記圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを３から３．５％の範囲とし、前記ＰＴｃと前記ＰＴｓの比をほぼ等しく設定してフィルタ機能用途としたことを特徴とする請求項１記載の弾性表面波装置。

【請求項１０】　前記すだれ状電極の電極指の対数Ｍが５０から２５０対としたことを特徴とする請求項８記載の弾性表面波装置。

【請求項１１】　前記圧電体平板が水晶であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを２から５％の範囲とし、ＰＴｓ／ＰＴｃ＝１．００７から１．０２としたことを特徴とする請求項１記載の弾性表面波装置。

【請求項１２】　前記すだれ状電極の電極指の対数Ｍが１００から３００対としたことを特徴とする請求項１１記載の弾性表面波装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は弾性表面波を利用して構成される共振子および共振子型フィルタ、さらにはトランスバーサル型フィルタ等の分野において、サイズの小型化を実現した弾性表面波装置に関する。

【０００２】

【従来の技術】従来の弾性表面波装置における第１の種類として、共振子および共振子型フィルタ等が知られている。これらは、少なくとも１つのすだれ状電極（以降省略してＩＤＴと称す）と、少なくとも１対の反射器からなる（特公平７－７３１７７号公報，特公平４－５２００５号公報参照のこと）。また特開昭５８－１２４１８号公報には、前記ＩＤＴのみの共振子とこれを組み合わせた横多重モードフィルタの例が開示されている。さらにまた、特開平６－８５６０２号公報には、ＩＤＴのみの構成からなるＩＤＴ型共振子の例が挙げられている。

【０００３】また弾性表面波装置の第２の種類として、２重分割電極（８分の１波長電極のこと）からなるＩＤＴを用いたトランスバーサル型のフィルタ等がある（特公平２－４５３６８号公報）。

【０００４】

【発明が解決しようとする課題】しかし前述の第１の種類に属する従来技術である特公平７－７３１７７号公報、特公平４－５２００５号公報の場合には、反射器を使用する分だけ共振子，共振子型フィルタにおける弾性表面波の伝搬方向の寸法が長くなり、近年著しい発展を見せているＧＳＭ方式とかＰＨＳ方式の携帯電話に用いられる中間周波フィルタ（ＩＦフィルタ）に要求される素子の小型化ができないという課題があり、また従来の

特開昭５８－１２４１８号公報および特開平６－８５６０２号公報に示されたいわゆるＩＤＴ共振子の技術では、共振子のＱ値（共振先鋭度を示す数値）が数千と小さく、十分に小さな等価直列抵抗値が得られず、フィルタの挿入損失が大きくなるという欠点があった。

【０００５】また、トランスバーサル型のフィルタ（特公平２－４５３６８号公報）等の前述の第２の種類に属する従来技術では、８分の１波長の電極指を用いているために、素子の周波数が４００ＭＨｚと高くなった場合に、おおむね電極指幅が約１μｍとなり、製造において高価な露光装置等の製造装置を必要とするためコスト高になるという欠点があった。

【０００６】そこで本発明はこのような問題点を解決するもので、その第１の目的は、共振子および共振子型フィルタ等の弾性表面波装置において、その性能をできるだけ損なわずにさらに小型化をはかることである。また第２の目的は、共振子と同一の４分の１波長幅の電極指を用い ることで、高価な露光装置等の製造装置を必要とせず、従来と同一水準の性能を有するトランスバーサル型やＩＤＴ型のフィルタを低コストで市場に提供することにある。

【０００７】

【課題を解決するための手段】

（１）　本発明の弾性波表面装置は、圧電体平板上に、弾性表面波の位相伝搬方向に直交して正と負の極性の金属導体を交互に平行配置してなるすだれ状電極を形成し共振子として使用する弾性表面波装置において、前記すだれ状電極の電極指の導体幅は、利用する弾性表面波の波長λのほぼ4分の１となし、前記すだれ状電極は、少なくとも３つ以上の領域に区分されて、かつ中央付近の前記電極指周期長ＰＴｃが両側の領域の前記電極指周期長ＰＴｓに対して異なる値を有することを特徴とする。

【０００８】（２）　前記（１）において、前記圧電体基板とすだれ状電極による弾性表面波の伝搬に係わる分散関係を代表する係数ａが負の場合に於いては、ＰＴｃ＜ＰＴｓの条件を満たす周波数上昇型とし、前記係数ａが正の場合には、ＰＴｃ＞ＰＴｓの条件を満たす周波数降下型としたことを特徴とする。

【０００９】（３）　前記（１）において、すだれ状電極はＭ対の正負電極指を持ち、電極指の交差幅が中央で１の値を取るＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）の重み付けを有しており、かつＫの値を０．５＜ξ＜０．９として、Ｋ＝π／（ξＭ）で与えたことを特徴とする。

【００１０】（４）　前記（１）のすだれ状電極において、電極指の交差幅が中央で１の値を取るＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）の重み付けを有しており、かつＫの値を０．５＜ξ＜０．９として、Ｋ＝π／（ξＭ）で与え、かつ前記関数ＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）＝０となるＸの絶対値以上に於いてＷＦ＝０としたことを特徴とする。

【００１１】（５）　前記（２）において、前記ＰＴｓと前記ＰＴｃの比ＰＴｓ／ＰＴｃを１以上から、ほぼ前記すだれ状電極を反射器と見なした場合の反射中心周波数ｆＲ０とアドミタンスの最大値ｆＴ０の周波数の比ｆＲ０／ｆＴ０の範囲としたことを特徴とする。

【００１２】（６）　前記（２）において、前記ＰＴｃと前記ＰＴｓの比ＰＴｃ／ＰＴｓを１以上から、ほぼ前記すだれ状電極を反射器と見なした場合の反射中心周波数ｆＲ０とアドミタンスの最大値の周波数ｆＴ０の比ｆＴ０／ｆＲ０の範囲としたことを特徴とする。

【００１３】（７）　前記（１）において、圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを０．５から２％の範囲とし、ＰＴｓ／ＰＴｃを１から１．０２としたことを特徴とする。

【００１４】（８）　前記（１）において、圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを４から６％の範囲とし、ＰＴｃ／ＰＴｓ＝１．００８から１．０２、かつξの値を０．６から０．８５としたことを特徴とする。

【００１５】（９）　前記（１）において、圧電体平板が１２８°ＹカットＸ伝搬であり、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを３から３．５％の範囲とし、前記ＰＴｃと前記ＰＴｓをほぼ等しく設定してフィルタ機能用途としたことを特徴とする。

【００１６】（１０）　前記（８）において、すだれ状電極の電極指の対数Ｍが５０から２５０対としたことを特徴とする。

【００１７】（１１）　前記（１）において、圧電体基板が水晶であり、 前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを２から５％の範囲とし、ＰＴｓ／ＰＴｃを１．００７から１．０２としたことを特徴とする。

【００１８】（１２）　前記（１１）において、すだれ状電極の電極指の対数Ｍを１００から３００対としたことを特徴とする。

【００１９】

【発明の実施の形態】以下、本発明の実施の形態を図１から順を追って説明する。

【００２０】（実施例１）図１は本発明の弾性表面波装置に使用される電極パターンを平面図で表した一実施の形態である。図１中の各部位の名称は、１００は圧電体平板、１０１は正極性の給電導体、１０２は負極性の給電導体、１０３と１０４等はＩＤＴの電極指、各々の給電導体１０１と１０２に接続する１０５と１０６は外部導通のためのパッド、１０７，１０８，１０９および１１０等はＩＤＴ電極指交差幅Ｗ（Ｘ）を作る分割線、１１１は、１１２のＸ軸に直交する方向であるＹ軸であり、１１２は弾性表面波の位相伝搬方向を示すＸ軸であ

る。１００の圧電体平板は、水晶、タンタル酸リチウム、ニオブ酸リチウム等の圧電性を有する単結晶の表面を鏡面研磨したもの、さらにＺｎＯ等の圧電性薄膜を形成した基板等からなる。前記の１００上に形成されたＩＤＴ等の導体パターンは、アルミニウムおよび金等の導電性を有する金属膜を蒸着、スパッタ等の手段により薄膜形成した後、フォトリソグラフィ技術によりパターン形成して作られる。前記ＩＤＴは、正極性の給電導体１０１と負極性の給電導体１０２、これらに接続する正極性の電極指１０３と負極性の電極指１０４等から構成されるが、その電極指群は利用する弾性表面波（レーリー波またはリーキー波等）の位相進行方向（長手方向Ｘ軸）に対して直交して、平行かつ周期的に多数配置される。前記ＩＤＴの分割線１０７と１１０によって、正極性と負極性の電極指の交差幅をゼロとなしている。また、１０８と１０９のＩＤＴ分割線は、正極と負極の電極指の交差する幅寸法であるＷ（Ｘ）がＣＯＳ（ＫＸ）の重み付けを有している。さらにまた、前記ＩＤＴを構成する電極指周期長ＰＴ（Ｘ）は、後述する図２において、特定の規則によりＸ座標位置により階段的な変化を与えてある。

【００２１】（実施例２）次に図２は、本発明の他の実施例を用いて、前述の図１における電極指周期長ＰＴ（Ｘ）の具体的設定例を示したものである。図中の各部位の名称は、２００は圧電体平板、２０１の点線で囲まれた範囲は、ＩＤＴ型ＳＡＷ共振子、２０２と２０９は外部接続のためのパッドである。２０３と２０４の破線で囲まれる領域は電極指交差幅がゼロの領域であり、２１４の破線で示される領域は、一様な電極指交差幅を有する領域である。２０５と２０６等は電極指、２０７と２０８等は給電導体である。２１２の階段状関数ＦＰ（Ｘ）は、前記ＩＤＴの電極指長を決定する周波数ポテンシャル関数と名付けてよいものであり、２１３の曲線Ｖ（Ｘ）は、図２の実施例で得られる振動変位関数である。

【００２２】前記２１２の周波数ポテンシャル関数ＦＰ（Ｘ）は、圧電体平板２００の種類と材質により決定される。図２の例の場合は、水晶ＳＴカット－Ｘ伝搬基板のような場合での設定であり、電極指の周期長ＰＴ（Ｘ）はＸ軸の中央程短く階段状に設定されている。前記のＰＴ（Ｘ）は、V_Sをアルミニウム膜がない場合の弾性表面波の速度として、次式（１）にて設定される。

【００２３】

【数１】

$$(1+FP(X))\,f_{R0}=V_S/(2\cdot PT(X)) \qquad (1)$$

【００２４】式（１）中の基準となる周波数f_{R0}は、前記ＰＴ（Ｘ）＝PT_0（一定）とした場合に生じる図２形状のＩＤＴ型ＳＡＷ共振子において、正負電極パッド２０２と２０９間を短絡して生じる、電極指導体群が作る反射特性の中心周波数である。

【００２５】前記のＦＰ（Ｘ）は周波数変化率の次元を有する。

【００２６】また、図２中の周波数変化率で表したζ_i（ｉ＝０～３）は、式$f_i=V_S/(2\cdot PT_i(X))$で与えられる周波数を用いて、

【００２７】

【数２】

$$\zeta_i=(f-f_{R0})/f_{R0} \qquad (2)$$

【００２８】で与えられる。ことにζ_0は、アルミニウム膜の無い場合の周波数f_0に対応し、$f_0=V_S/(2\cdot PT_0)$で与えられる。図２のＦＰ（Ｘ）により得られる振動変位Ｖ（Ｘ）は、ほぼＩＤＴ型共振子の中央で最大となる余弦関数（ＣＯＳ（ＫＸ））状の変位を有し、Ｘ軸方向に関して、いわゆる振動エネルギ閉じ込め現象が実現している。この現象が発生する理由を、次の図３を用いて説明する。

【００２９】図３において、３００と３０１は給電導体、３０５と３０６等はＩＤＴの電極指、３０２の線で囲まれた領域は第１の電極指の周期長PT_1（$=L_{n-1}+S_{n-1}$）を有するＩＤＴ領域、同様に３０３は第２の電極指の周期長PT_2（$=L_n+S_n$）を有するＩＤＴ領域、３０４は第３の電極指の周期長PT_3（$=L_{n+1}+S_{n+1}$）を有するＩＤＴ領域である。また、図中に記載されたω_1，ω_2，ω_3は、対応する領域のＩＤＴが有するアドミタンス特性のほぼ最大点の角周波数（$\omega_0=2\pi f_{T0}$）、あるいはブラッグ周波数と言われるものである。また枠で囲まれた中の図は、前記各ＩＤＴがもつ波数分散曲線を記述したものであり、この特性は縦軸を角周波数$\omega=2\pi f$軸、横軸を弾性表面波の振動振幅Ｖ（Ｘ）の作る波数Ｋとして図示したものである。また、図３の左半面はＫの虚数部を右半面はＫの実数部を表している。３０７の波数分散曲線はＩＤＴ領域３０２のものであり、３０８は３０４のＩＤＴ領域のものである。前記の分散曲線は、おおむね次式（３）で近似できる。

【００３０】

【数３】

$$\omega/\omega_0=1+a\gamma^2 \qquad (3)$$

【００３１】ここで、ω_0は前記のブラッグ周波数、ａは係数、γは前記Ｋを弾性表面波の波長λで与えられる波数k_0（$=2\pi/\lambda$）規格化した規格化波数である（$\gamma=K/k_0$）。曲線３０７、３０８はａが負の場合である。係数ａは基板の種類、方位、弾性表面波の種類により決定されることを付け加える。波数分散曲線が虚数値をとる状態の弾性表面波は、伝搬できずに反射され、反対に実数の波数をもつ弾性表面波は伝搬可能である。中央のＩＤＴ領域３０３において、ω_2の角周波数を有する弾性表面波がＸ軸の両側に放射されるわけであるが、まずＩＤＴ３０２側に進行した弾性表面波の状

態は、分散曲線３０７のＰ２点の波数Ｋ２（実数）を有するため伝搬できる。一方右側のＩＤＴ３０４の領域に進行した弾性表面波は、分散曲線３０８のＰ１点の波数Ｋ１（虚数）をとるため、伝搬できずに反射される。従って以上から言えることは、前記係数ａが負で、かつＩＤＴの周波数設定状態が　$\omega_1 > \omega_2 > \omega_3$　の関係にある場合においては、弾性表面波はＸ軸の正方向には伝搬できずに反射され、その振幅は減衰するということである。さらにこれを押し進めて、$\omega_1 < \omega_2 > \omega_3$　の関係を作れば、弾性表面波は、ω_2の角周波数を有する中央ＩＤＴ領域に閉じ込められることになり、前述の図２中の２１３　Ｖ（Ｘ）の振動変位が実現することになる。前記ω_1，ω_2，ω_3は、$\omega_1 = 2\pi f_{T1}$，$\omega_2 = 2\pi f_{T2}$，$\omega_3 = 2\pi f_{T3}$　とおいて式（２）の関係で順に、ζ_2，ζ_1，ζ_2と対応させることができる。

【００３２】つぎに図４を用いて、図１と図２中の圧電体平板の具体例として１２８°Ｙ－$XLiNbO_3$ 基板の例を用いて、本発明の弾性表面波装置の構成法を説明する。図４のＩＤＴは、電極指幅Ｌが４分の１波長（λ／４）の長さで構成されている。

【００３３】図４の横軸は、アルミニウム電極膜厚Ｈに対する弾性表面波の波長λの比Ｈ／λであり、縦軸は周波数変化率Δｆ／ｆをｐｐｍ単位で表示している。曲線４００は前記ＩＤＴのもつアドミタンス最大点の周波数f_{T0}を、アルミニウム膜が無い場合の周波数$f_0 = V_S/(2 \cdot P_{T0})$を基準値０として、周波数変化率で表示している。曲線４０１は、前記ＩＤＴのもつ反射特性の中心周波数f_{R0}の電極指膜厚比Ｈ／λ　依存性を図示している。４０２は、４０２と４０１の周波数差が、４０１と４００の周波数差に等しくなるようにとって描いたもので、４００と４０２で挟まれた領域が弾性表面波の反射領域即ち、ストップバンドを表している。曲線４００と４０１は、ほぼＨ／λ＝３．２において交差しており、この状態においては、前記ストップバンドが消滅しており、弾性表面波は反射されずに伝搬する。従って、この膜厚比の条件においては、トランスバーサル型とかＩＤＴ型とかの弾性表面波の反射をきらう素子であるフィルタの構成が、電極指幅Ｌがほぼ４分の１波長（λ／４）の長さで実現できる。 実効的にはＨ／λが３～３．５％程度の範囲で反射係数は十分小さく効果的である。Ｈ／λが３．２以下の領域においては、　$f_{T0} < f_{R0}$　の状態にあり、この領域の弾性表面波は図中に重ねて図示した分散曲線４０３と４０４の特性となり、いわゆる前述の図２の例の通り、周波数上昇型閉じ込め状態を示す。逆に、 Ｈ／λが３．２以上の領域においては、　$f_{T0} > f_{R0}$　の状態にあり、この領域の弾性表面波は図中に重ねて図示した分散曲線４０５と４０６の特性となり、前述の図２の例とは逆特性の、いわゆる周波数降下型閉じ込め状態を示す。まとめると、前述の図２の実施例は、前記の周波数上昇型閉じ込めに対応しており、 図４のＨ／λ＜３．２以下の領域に対応した構成法である。 Ｈ／λ＞３．２の場合には、図２のζ_1からζ_3を負として設定すれば周波数降下型エネルギ閉じ込め状態を構成できる。つぎに、このようにして得られる本発明の弾性表面装置の振動変位状態を図５で説明する。

【００３４】図５の横軸５０４は弾性表面波装置のＸ座標、縦軸５０３は素子の振動エネルギＥ（Ｘ）（振動変位振幅Ｕの２乗に比例）を表す。図中の曲線５００から５０２は条件別の振動エネルギ分布を示す関数である。前記条件となるものは、前述の図２のＩＤＴ２０１を３分割し、その中央のＩＤＴの周波数上昇量Ｐ（周波数ポテンシャル）を前記$|f_{T0} - f_{R0}| = \eta$を単位として、５００の場合はＰ＝０η、５０１の場合は、Ｐ＝０．８η、５０２の場合は、Ｐ＝１．２ηと設定した場合である。同図からわかる通り、周波数上昇量０に対してＰがゼロでない場合には、振動エネルギの中心集中度が増していることがわかる。

【００３５】この現象をさらにわかり易く表したものが、図２の弾性表面波装置である共振子のＱ値を示す特性図（図６）である。周知の様に共振子のＱ値は共振子のエネルギ損失の程度を表し、Ｑが大きい程損失の少ない良い共振子である。図６の横軸は中央ＩＤＴの前記周波数上昇量Ｐであり、縦軸はＰ＝０の場合の共振子Ｑ値Q_0を基準として表している。η＝８０００ｐｐｍとしてＰ＝１．２ηのときに、約４倍のＱ値が得られていることがわかる。Ｑ値上昇効果が認められる前記Ｐの具体的な値は、水晶ＳＴカットＸ伝搬方位の場合は、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを２から５％の範囲とし、７０００～２００００ｐｐｍであつた（このとき中央の電極指周期長ＰＴｃと両サイドの電極指周期長ＰＴｓの比はＰＴＳ／ＰＴｃ＝１．００７～１．０２である）。１２８°Ｙ－$XLiNbO_3$ 基板の場合には、前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを４から６％の範囲とし、８０００～２００００ppmであった（このとき中央の電極指周期長ＰＴｃと両サイドの電極指周期長ＰＴｓの比はＰＴｃ／ＰＴｓ＝１．００８～１．０２である）。さらに圧電体平板が１２８°ＹカットＸ伝搬であり、 前記電極指の膜厚Ｈに対する弾性表面波の波長λとの比Ｈ／λを０．５から２％の範囲とし、ＰＴｓ／ＰＴｃ＝１から１．０２としてもＱ値向上が実現できる。前記ＩＤＴに使用した正負電極指の対数は、１２８°Ｙ－$XLiNbO_3$ 基板の場合には、５０～２５０対、水晶ＳＴカットＸ伝搬方位の場合は、１００から３００対の範囲である。

【００３６】つぎに、本発明の弾性表面波装置に発生する不要共振、即ちスプリアスについての抑圧手段を説明する。一例として、前述の１２８°Ｙ－$XLiNbO_3$ 基板の例をとり説明する。前記の基板において、電極膜厚比

H／λを０．０５に設定して周波数降下型のエネルギ閉じ込め型共振子を構成すると、縦インハーモニックモードによるスプリアスは主共振モードであるＳ０モードの上側に発生する。図８にこの様子を示す。図中の点線で表示された８０４、８０５のモードがスプリアスである。８０２は前記主共振モード、８０３は反共振モードである。

【００３７】そこでこのスプリアスを抑圧するために、前記ＩＤＴの電極指交差幅に重み付け関数ＷＦ（Ｘ）＝ＣＯＳ（ＫＸ）を考え（図１参照）、前記Ｋの設定をＫ＝π／（ξＭ）で与えた場合における、前記ξを重み付け長さ比と呼んで、ξに対するスプリアス共振による共振子のインピーダンスの位相変動量Δφの関係を図示したものが、図７である。位相変動量Δφはスプリアスモードの発生強度を表しているから、Δφが小さいほどスプリアスの抑圧ができたことになる。前記Ｘ波弾性表面波の波長λで規格化したＸ（＝ｘ／λ）軸方向の座標である。図７の曲線７００は、周波数上昇量Ｐ＝０の場合であり、このときξ＝０．８が最小値であり、曲線７０１の場合は前記Ｐ＝０．８ηであり、このとき０．６５が最小値であった。７０２はＰ＝１．２ηの場合であり、このときの最小値は０．５であった。

【００３８】従って１２８° Ｙ－ＸＬｉＮｂＯ$_3$ 基板の場合には、ξ＝０．５から０．９の範囲に対して、Ｐ＝０から１．２の条件でのスプリアスが抑圧できる。他の基板方位に関しても、ほぼ同様な傾向を示した。

【００３９】

【発明の効果】以上述べたように本発明によれば、反射器を用いずＩＤＴのみで共振子を構成し、前記ＩＤＴを複数に分割したうえに、各分割されたＩＤＴの電極指周期長を使用する圧電基板の性質が、周波数上昇型か周波数降下型かに対応して周波数ポテンシャルを共振子の振動エネルギが中央に集中して閉じ込められる様に設定することにより、従来になく小型で性能のすぐれたＩＤＴ

型共振子と、これを用いて横および縦多重モード型の共振子型フィルタが実現できるため、さらに小型化が要求されるＰＨＳ、ＧＳＭ等の携帯型通信装置およびＶＣＳＯ等の小型化に貢献できる。また、余弦関数ＣＯＳ（ＫＸ）のＫを適正にして前記ＩＤＴの電極指重み付けを行うことにより、縦インハーモニックモード群からなるスプリアスを抑圧することが可能となり、フィルタ等に本発明の弾性表面波装置を用いた際に、前記スプリアスに妨害されずに優れた減衰特性を得ることができる。

【００４０】さらにまた、１２８° Ｙ－ＸＬｉＮｂＯ$_3$ 基板において、電極指の膜厚比Ｈ／λをほぼ０．０３２と設定することにより、電極指幅Ｌが４分の１波長でも弾性表面波の反射の起きない状態が実現できるために、高度な加工装置を使わなくても数百ＭＨｚのＳＡＷフィルタが実現でき素子コストの低減が可能となり、今後多大の利益が期待できる。

【図面の簡単な説明】

【図１】　本発明の弾性表面波装置の一実施例を示す平面図。

【図２】　本発明の他の実施例が示す図。

【図３】　本発明の弾性表面波装置の動作原理を解説する概念図。

【図４】　本発明の一実施例が示す圧電体平板の特性図。

【図５】　本発明の図１と図２が有する特性図。

【図６】　本発明の図１と図２が有する特性図。

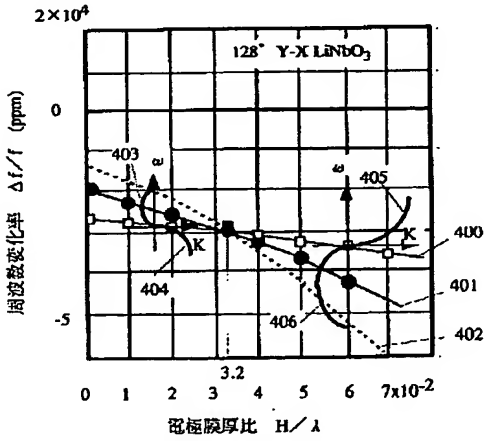
【図７】　本発明の図１が有する特性図。

【図８】　本発明の図１が示す他の特性図。

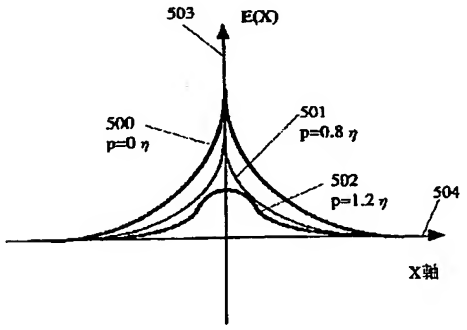
【符号の説明】

１００　圧電体平板
１０１　正極の給電導体
１０２　負極の給電導体
１０３　正極の電極指
１０４　負極の電極指

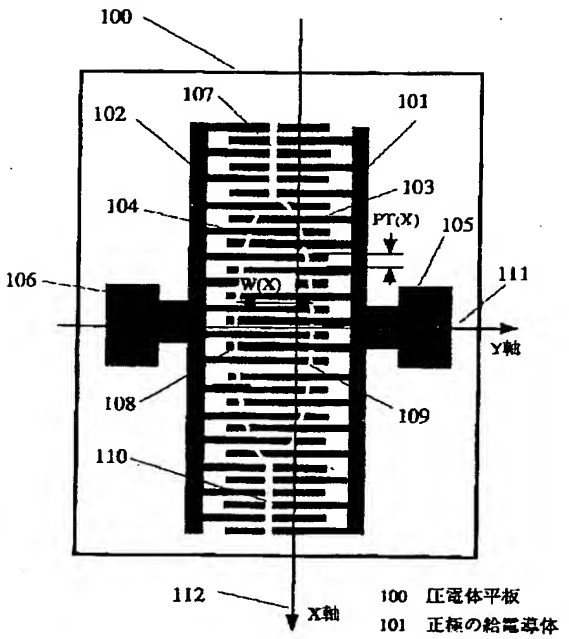
【図４】



【図５】

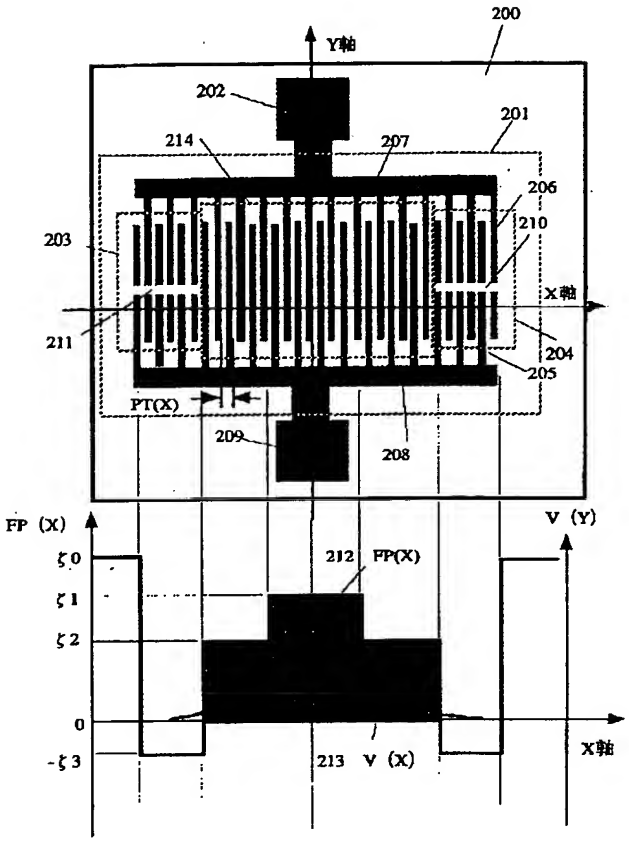


【図１】

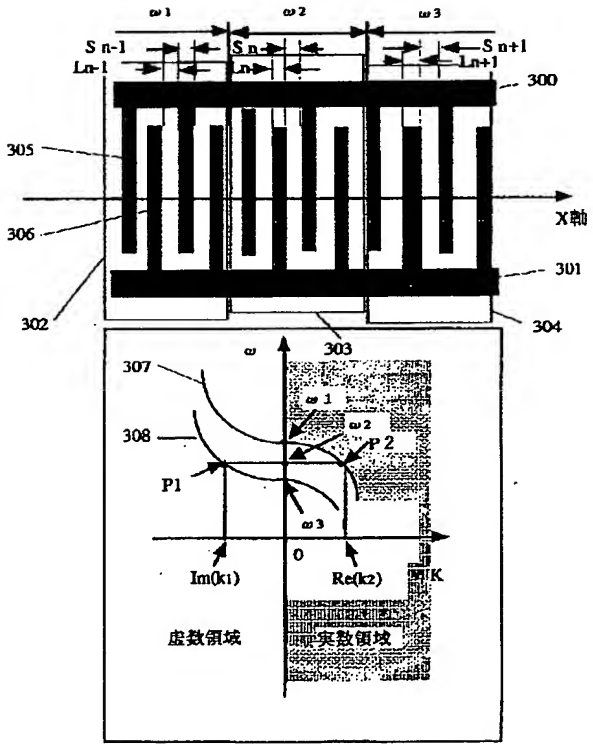


100 圧電体平板
101 正極の給電導体
102 負極の給電導体
103 正極の電極指
104 負極の電極指

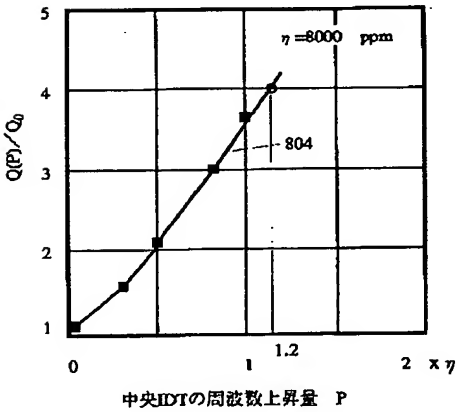
【図２】



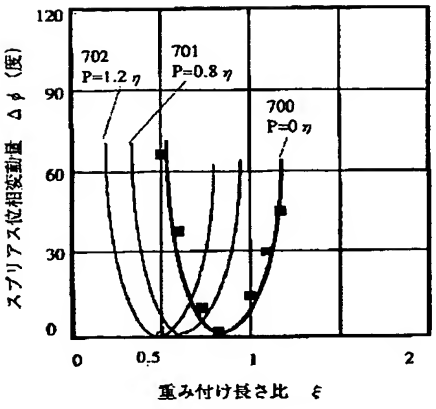
【図３】



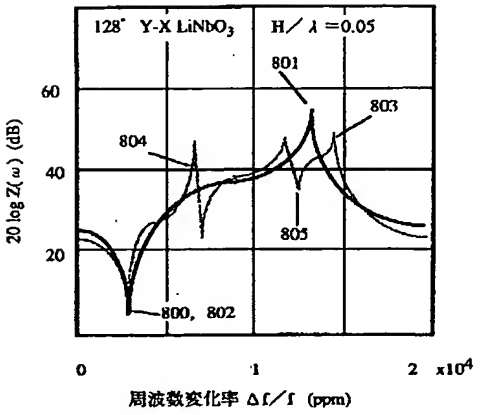
【図６】



【図７】


120
90
60
30
0
0
0.5
1
2
702
P=1.2 η
701
P=0.8 η
700
P=0 η
スプリアス位相変動量 Δφ (度)
重み付け長さ比 ξ

【図８】


128° Y-X LiNbO3
H/λ =0.05
801
803
804
805
800, 802
60
40
20
0
1
2 x10^4
20 log Z(ω) (dB)
周波数変化率 Δf/f (ppm)